Project	CCN S2 Asia_VOL_SPA2_22_TCM_TRM
Customer	VOLVO CAR CORPORATION
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VOLVO approval			

VERSION HISTORY:

Change reasons (CR):

1 HW Change
2 SW Change
3 Change requirements on behalf of the customer
4 Continental TEMIC change requirement
5 TBD (to be defined)
6 Unclear formulation
7 Editing changes (spelling mistakes, layout, etc. without any content changes)

Version	Date	Author	Comment, Description
1.0	30.07.2020	Madalina Davidescu	1st draft
1.1	03.09.2020	Madalina Davidescu	Update test flow in days; Define Ch. Connector pins push/pull; Define Ch. Visual Inspection;
1.2	13.10.2020	Madalina Davidescu	Update version history; Since VCC are not requesting Base Variant anymore-removed; Added RTU configuration for US market;
1.3	12.01.2021	Madalina Davidescu	Update version history; Update Ch. 1.1 - Change number of DUTs; Update Ch1.1. – Add again BASE and RTU variants; Update number of samples for each test; Update test flow for DV and PV
1.4	25.01.2021	Madalina Davidescu	Update Ch.1.1- VCC part number; Update Ch.1.7. (Condition/ action for fully electric towbar);
1.5.	23.04.2021	Madalina Davidescu	Update checkers list (add new viewer and responsible); Update Ch. 1.2 – General test conditions (temperature value, tolerances); Update Ch. 1.6 -Test flow (number of samples) Update Ch. 1.7 - Operating mode (define UB and UA values); Update Ch. 1.8 – Functional status classification (add additional definitions of FSC- Class B according to " Supplement to ISO 16750"); Update Ch. 1.9 – DUT Test Position ; Update Ch.3 – define the parameter "t_1" Update Ch.4 -test parameters and test procedure; Update Ch.5 -test parameters, test procedure and acceptance criteria; Update Ch.6 -test parameters, insert vibration DUT test position, test procedure and acceptance criteria; Update Ch.7 -test parameters, test procedure and acceptance criteria; Update Ch.8 -test parameters, note, test procedure and acceptance criteria; Update Ch.9-test parameters, test procedure (define t_1) and acceptance criteria; Update Ch.10 -test parameters, deviation, acceptance criteria; Update Ch.11 - test procedure and acceptance criteria; Update Ch.12 – applicable standard, test procedure and acceptance criteria;

			Update Ch.14 –acceptance criteria; Update Ch.15– test parameters (insert table with size of each connector pins) and acceptance criteria; Update Ch.16– test procedure ("Remove the chemical agents from the DUT surfaces using a dry tissue") and acceptance criteria; Update Ch.17– insert test procedure and acceptance criteria; Update Ch.18– insert test procedure, picture with testing points and acceptance criteria; Update Ch.19– initial evaluation test; Rename Ch.20 " Visual inspection general test"
1.6.	14. 06.2021	Madalina Davidescu	According to the customer comments added : Ch.1.6a and Ch. 1.6b Insert clear picture of test flow; Ch.10- Description arranged in different order; Ch.11 – Better arangemnet in sentences description; Ch.12 –Added edition date for standard. Redefine "temperature profile" according standards mention above; Ch.13- Updated with correct DUT test position;

TABLE OF CONTENT

1. GENERALS

This Qualification Test Plan describes the required measurement and tests for the devices CCN VOL_SPA2_22_TCM_TRM.

The VOL_SPA2_22_TCM_TRM is a TRAILER CONTROLE MODULE for Volvo platform. VOL_SPA2_22_TCM_TRM project considering development of 3rd generation of trailer control module for Volvo Cars Company.

The tests should be carried out on a random sample component retrieved from the pre-series production. The components must feature at least zero series condition and must have been produced at the location of the series production with series-production equipment.

The SPA2 TRM module comes in two variants; RTU and BASE. Both variants can control all the lights of a trailer, provides two additional power lines, but RTU variant and has the possibility to be connected to a Retractable Tow-bar Unit (RTU).

The ECU is connected to car battery via Trailer Input Power (TRLR_PWR_40) and Trailer Input Permanent Power (TRLR_PWR_20), fused by 40A and 20A respectively. The communication between ECU and the vehicle is done via CAN bus.

1.1.PURPOSE

The purpose of this document is to describe the DV/PV/Requalification environmental qualification program that must be successfully completed in order for Continental Automotive and the customer to consider the assembly qualified for use in the end application for which it was designed. This specification was developed in accordance with the customer environmental test specifications and international standardization and is valid for the following sample variant:

Variant name	VCC part number	Conti part number identification	No. of parts to be tested
Volvo SPA 2 TRM without the RTU (retractable tow bar function)	32351303	A3C0666760XXX	US configuration – 2 part to be tested on each test sequence
Volvo SPA TRM –with RTU	32147051	A3C0666770XXX	EU configuration – 4 parts to be tested on each sequence

The requalification test has to be done every year, the period between two requalification tests should not be more than 12 ± 2 month. A new sample report because of major changes replaces the requalification tests if the afterwards agreed tests are all part of the performed tests.

1.2. GENERAL TEST CONDITIONS

All DUTs have to be clearly marked by the development department. Use of original connectors and similar cable harnesses is mandatory. Deviations need to be mentioned in the test order. Use of new cable harness is recommended.

Unless otherwise specified, all tests shall be performed at:

Standard atmospheric conditions for measurement and tests	
Temperature [1)]	(23±5)°C
Relative Humidity [1) 2)]	25 to 75 %
Air Pressure [1)]	86 kPa to 106 kPa (860 mbar to 1060 mbar)
[1)] Inclusive extreme values	[2)] Absolute humidity 22 g/m³
General Definitions	
Room Temperature (RT)	(23 ±5)°C
Operation temperature range T_{min}	-40°C
Operation temperature range T_{max}	+85°C
Minimum Power Supply (U_{min})	(9±0,1) V
Nominal Power Supply (U_{nom})	(14±0,1) V
Maximum Power Supply (U_{max})	(16±0,1)V
Battery voltage (UB)	12.0 V
Engine/alternator running (UA)	14.0 V
Temperature Reference Point	Ambient temperature (chamber temperature)
Thermal equilibrium	State when the temperature of all parts of the DUT are within 3 °C, or as otherwise described by the relevant specification of the final temperature (acc. IEC 60068-1)

Default tolerances during qualification	
Parameter	**Tolerance**
Frequency and time	± 5 %
Voltages	± 0,1 V
Current	± 5 %
Resistance	± 10 %
Temperature	± 10 %

1.3. GLOSSARY / ABBREVATIONS

ABBREVIATION	TRANSCRIPTION
CAN	Controller Area Network
DUT	Device Under Test
DV	Design Validation
DPR	Design Prerequisites
ECU	Electronic Control Unit
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ISO/TS	International Organization for Standardization /Technical Specification
FSC	Functional Status Classification
KL_15	Clamp 15, meaning “Ignition Power”
KL_30	Clamp 30, meaning “Permanent Power Supply”
LED	Light Emitting Diode
OM	Operating mode
PWM	Pulse Width Modulation
PSD	Power Spectral Density
PV	Product Validation
QP	Qualification Program
QL	Qualification Laborator
QMP	Quality Manager Project
RH	Relative Humidity
RMS	Root Mean Square
RT	Room Temperature
RTU	Retractable tow bar unit
t	Time
T	Temperature
TCM	Transmission Control Module
TEL	Test Engineer Product Launch
TPL	Technical Project Leader
TF	Test Flow
TRM	Trailler Module
SPA	Scalable Platform Architecture
PPAP	Production Part Approval Process
VCC	Volvo Car Corporation

1.4. REFERENCED STANDARDS AND DOCUMENTS

Originator	Version/Date	Description of document
Customer	NOTE-DPR 33718830 Rev 06 (2020-09-01)	DESIGN PREREQUISITES, SYSTEM/COMPONENT, DPR Trailer Module SPA2- PRELIMINARY
	NOTE- SPEC 31822854 Rev 15 (2019-07-09)	Volvo Car Corporation. Supplement to ISO 16750
International Standards	ISO 16750-1 (2018-11)	Road vehicles — Environmental conditions and testing for electrical and electronic equipment —(Part 1: General)
	ISO 16750-3 (2012-12-15)	Road vehicles — Environmental conditions and testing for electrical and electronic equipment (Part 3: Mechanical loads)
	ISO 16750-4 (2010-04-15)	Road vehicles — Environmental conditions and testing for electrical and electronic equipment (Part 4: Climatic loads)
	ISO 16750- 5 (2003)	Road vehicles — Environmental conditions and testing for electrical and electronic equipment (Part 5: Chemical loads)
	ISO 20653 (2013-02-15)	Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access.
	IEC 60068-2-1 Ab (2007-03)	Environmental testing - Part 2-1: Tests - Test A: Cold
	IEC 60068-2-2 Bd (2007-07)	Environmental testing - Part 2-2: Test B: Dry heat
	IEC 60068-2-6	Test Fc: Vibration(2007);
	IEC 60068-2-11 Ka (1981)	Basic Environmental Testing Procedures; Part 2: Tests; Test Ka: Salt mist
	IEC 60068-2-14 Na (2009-01)	Basic Environmental Testing Procedures; Part 2: Tests; Test N: Change of temperature
	IEC 60068-2-14 Nb (2009-01)	Basic Environmental Testing Procedures; Part 2: Tests; Test N: Change of temperature
	IEC 60068-2-27	Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock
	IEC 60068-2-30 (2005-08-01)	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic
	IEC 60068-2-31 (2008-05)	Environmental testing - Part 2-31: Tests - Test Ec: Rough Handling Shocks, primarily for equipment-type specimens
	IEC 60068-2-38 (2009-01)	Environmental testing. Part 2: Tests. Test Z/AD: Composite temperature/humidity cyclic test
	IEC 60068-2-64 (2019-10)	Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance
	IEC 60068-2-78 (2012-10-01)	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state
	DIN 75220 (1992-11-01)	Ageing automobile components in solar simulation units
	DIN EN 13018 (06.2016).	Non-destructive testing - Visual testing - General principles;
	SAE/USCAR-2 (Revision 5 from 2007-11)	Performance specification for automotive electrical connector systems

1.5. TEST SELECTION

(according NOTE-DPR 33718830, Chapter 5.1.9.2)

Test	Test required	Operating mode	Comment
High temperature storage	DV, PV	1.1	N/A
Temperature cycling with specified temperature change rate	DV, PV	3.3/1.2	N/A
Rapid change of temperature with specific transition duration	DV, PV	1.1	N/A
Random and sinusoidal vibration and temperature cycling	DV, PV	3.3- sinus 3.1./3.2 Random	N/A
Composite temperature/ humidity cycle test	DV, PV	3.3/2.1	N/A
Damp heat, steady state	DV, PV	2.1/3.3	N/A
Low temperature storage	DV, PV	1.1	N/A
Low temperature operation	DV, PV	3.3	N/A
High temperature operation	DV, PV	3.4	N/A
Temperature steps	DV, PV	1.2/3.3	N/A
Mechanical shock	DV, PV	3.2	N/A
Drop test	DV, PV	1.1	N/A
Connector pins push/ pull	DV, PV	1.1	N/A
Chemical loads	DV, PV	1.1	N/A
IP -Protection against foreign objects	DV, PV	1.1	N/A
IP -Water intrusion	DV, PV	1.2	N/A
Temperature storage test	PV	1.1	N/A
Visual inspection general test	DV, PV	-	N/A

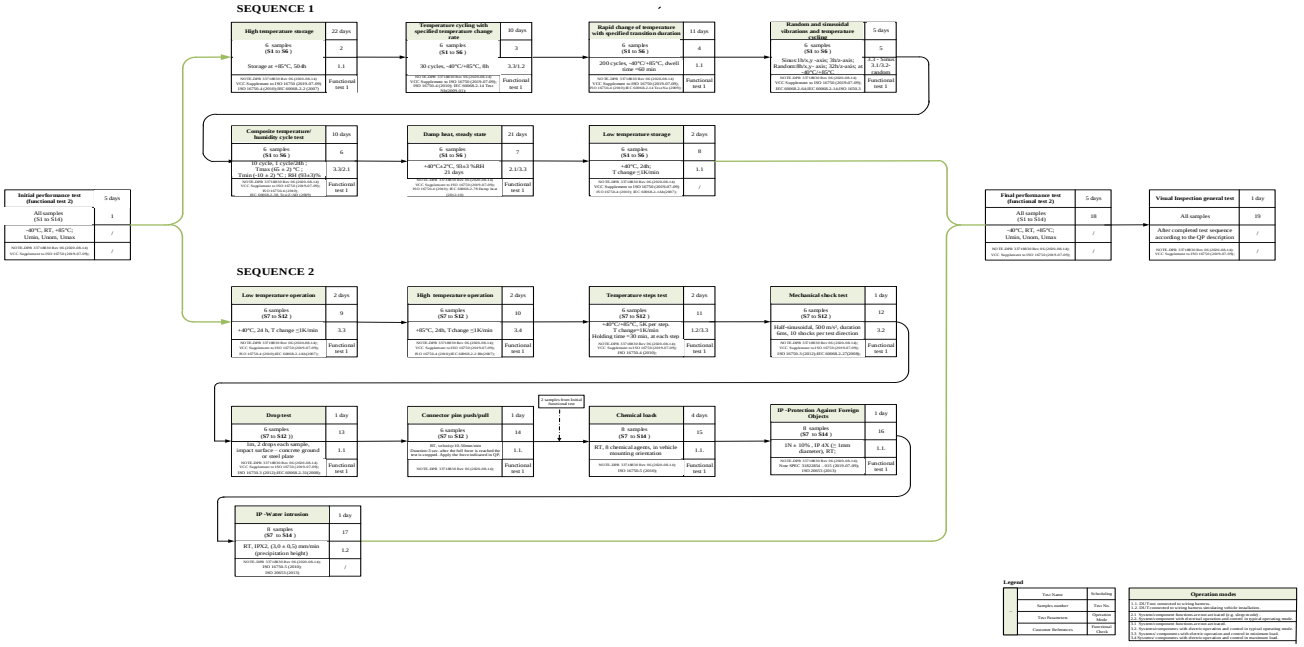
The test schedule is divided into two different processes:

- Sequence 1
- Sequence 2

1.6a. TEST FLOW FOR DESIGN VALIDATION

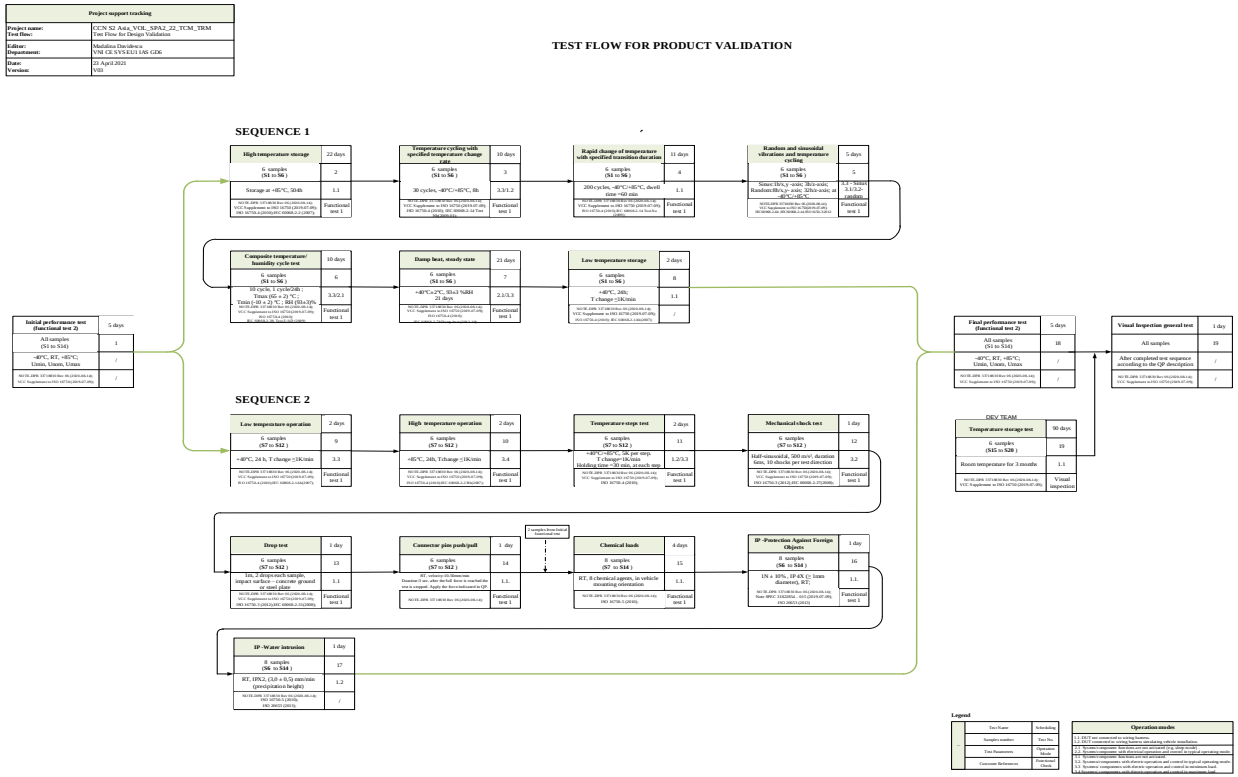
Project support tracking	
Project name: **Test flow:**	CCN S2 Asia_VOL_SPA2_22_TCM_TRM Test Flow for Design Validation
Editor: **Department:**	Madalina Davidescu VNI CE SYS EU1 IAS GD6
Date: **Version:**	23 April 2021 V01

TEST FLOW FOR DESIGN VALIDATION



Designed by : Madalina Davidescu	Date: 14.06.2021	Depart: VNI CE SYS EU1 IAS GD6	Sign:
Continental	Document name: Qualification Program	Project:CCN S2 Asia VOL_SPA2_22_TCM_TRM	
	Document : QP_ENV_VOL_SPA2_22_TCM_TRM		Pages:10
Continental Iasi (VNI) 2021			

1.6.b. TEST FLOW FOR PRODUCT VALIDATION



Designed by : Madalina Davidescu	Date: 14.06.2021	Depart: VNI CE SYS EU1 IAS GD6	Sign:
Continental	Document name: Qualification Program	Project:CCN S2 Asia VOL_SPA2_22_TCM_TRM	
	Document : QP_ENV_VOL_SPA2_22_TCM_TRM		Pages:11
Continental Iasi (VNI) 2021			

1.7. OPERATING MODE

The electric, electronic and mechatronic components and systems will be operated in different operating modes during their service life, which shall be simulated correspondingly during the tests. Details concerning the operating modes, operating loads (e.g. actuation, bus activity, bus messages, original sensors, original actuators or replacement circuitry) and the necessary boundary conditions shall be coordinated between the buyer and supplier and documented.

Operating Mode	**Electrical State**
Operating mode 1 - No voltage is applied to the DUT	
1.1	Not connected to wiring harness.
1.2	Connected to wiring harness simulating vehicle installation.
Operating mode 2 - The DUT is electrically operated with the test voltage U_B (12V) as in a vehicle with shut-off engine and with all electrical connections made.	
2.1	System/ component functions are not activated (e.g. sleep mode)
2.2	Systems/components with electric operation and control in typical operating mode.
2.3	Systems/components with electric operation and control in minimum load.
2.4	Systems/ components with electric operation and control in maximum load.
Operating mode 3 - The DUT is electrically operated with test voltage U_A (14V) with all electrical connections made	
3.1	System/ component functions are not activated
3.2	System/ components with electric operation and control in typical operating mode.
3.3	Systems/ components with electric operation and control in minimum load.
3.4	Systems/ components with electric operation and control in maximum load.

Typical operating mode for DV/PV

This is the specification for test sequence to be continuous run during DV/PV Environmental test. Normally EU configuration and test setup is used. For tests where more than one DUT is used, one DUT shall be used in US configuration / test setup.

EU Configuration

The tables below describes 3 different profiles for the TRM channels. Note that this is the channel activation according to CAN signalling.

Channel profile by CAN signaling				
TRM channel	**0**	**1**	**2**	**3**
Direction indicator, left	Off	Off	On	Off
Direction indicator, right	Off	Off	On	Off
Position light, left	Off	Off	On	Off
Position light, right	Off	Off	On	Off
Stop light	Off	Off	On	Off
Fog light	Off	Off	On	Off
Reversing light	Off	Off	On	Off
Kl_15	Off	Off	On	Off
Kl_30	Off	Off	On	Off

HW stop line input	Off	PWM 200Hz 50%	On	Off
RTU	Off	Off	Off	On

The table below describes 3 different profiles for switching trailer light on loads. The load power shall be according nominal values (Note: for Environmental test, test currents for ignition power and permanent power shall not lower than 15A).

	Load profile setup		
Trailer load	**0**	**1**	**2**
Direction indicator, left	Off	On	Off
Direction indicator, right	Off	On	On
Position light, left	Off	On	On
Position light, right	Off	On	On
Stop lights	Off	On	On
Fog light	Off	On	On
Reversing light	Off	On	On
Kl_15	Off	On	On
Kl_30	Off	On	On

The table below describes the sequence and the criteria to pass each step.

Step	**Channel profile**	**Load profile**	**Duration**	**Specific pass criteria**
1	0	0		Trailer detection = 0
2	1	1		Stop light activated. No PWM.
3	2	1		Trailer detection = 1. Lights according to load profile
4	2	2		TrailerChecklamp indicating lamp failure
5	3	0		According to following table

The table below shows test procedure, pass criteria and signals should be monitored for RTU.

Step	**Condition/Action for semi-electrical**	**Pass Criteria**	**Monitored Signals**
1	Towbar in lock position	Towbar in lock position	Motor supply, Hall sensor and signal, saftey switch and LEDs
2	Active release switch	Towbar in released position	Motor supply, Hall sensor and signal, saftey switch and LEDs
3	Return towbar in lock position	Towbar maintains in lock position	Motor supply, Hall sensor and signal, saftey switch and LEDs

Step	Condition/Action for fully electric towbar	Pass Criteria	Monitored Signals
1	Towbar is InFolded (Rest position)	Towbar is InFolded (Rest position)	TrlrTwbrPos , uSW1 & uSW2, Motor supply
2	Send FoldOut signal	Towbar is MovingOut	TrlrTwbrPos , uSW1 & uSW2, Motor supply
3	Towbar OutFolded (Working position)	Towbar OutFolded (Working position)	TrlrTwbrPos , uSW1 & uSW2, Motor supply
4	Send FoldIn signal	Towbar is MovingIn	TrlrTwbrPos , uSW1 & uSW2, Motor supply

US Configuration

The tables below describes 3 different profiles for the TRM channels. Note that this is the channel activation according to CAN signalling.

Channel profile by CAN signaling				
TRM channel	**0**	**1**	**2**	**3**
Direction indicator, left	Off	Off	On	Off
Direction indicator, right	Off	Off	On	Off
Position light, left	Off	Off	On	Off
Position light, right	Off	Off	On	Off
Stop light	Off	Off	On	Off
Fog light	Off	Off	On	Off
Reversing light	Off	Off	On	Off
Kl_15	Off	Off	On	Off
Kl_30	Off	Off	On	Off
HW stop line input	Off	PWM 200Hz 50%	On	Off
RTU	Off	Off	Off	On

The table below describes 3 different profiles for switching trailer light on loads. The load power shall be according nominal values (Note: for Environmental test, test currents for ignition power and permanent power shall not lower than 15A).

	Load profile setup		
Trailer load	**0**	**1**	**2**
Direction indicator, left	Off	On	Off
Direction indicator, right	Off	On	On
Position light, left	Off	On	On
Position light, right	Off	On	On
Stop lights	Off	On	On
Fog light	Off	On	On
Reversing light	Off	On	On
Kl_15	Off	On	On
Kl_30	Off	On	On

The table below describes the sequence and the criteria to pass each step.

Step	Channel profile	Load profile	Duration	Specific pass criteria
1	0	0		Trailer detection = 0
2	1	1		Stop light activated. No PWM.
3	2	1		Trailer detection = 1. Lights according to load profile
4	2	2		TrailerChecklamp indicating lamp failure
5	3	0		According to following table

1.8. FUNCTIONAL STATUS CLASSIFICATION

This element describes the functional status of a DUT during and after a test. The minimum functional status shall be given for each test.Unwanted operations of the DUT are not allowed in any of the following classes.Vehicle manufacturer and Continental shall specify operations that are not allowed.

Functional status classification	
Class A	All functions of the device/system perform as designed during and after the test.
Class B	All functions of the device/system perform as designed during the test. However, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after the test.Memory functions shall remain class A. It shall be specified by the vehicle manufacturer which function of the DUT needs to perform as designed during the test, and which function can be beyond the specified tolerance. Additional, for redundantly supplied DUTs, all functions of the device/system perform as designed during the test, but the redundancy of the DUT is temporarily degraded or lost.
Class C	One or more functions of a device/system do not perform as designed during the test but return automatically to normal operation after the test.
Class D	One or more functions of a device/ system do not perform as designed during the test and do not return to normal operation after the test until the device / system is reset by simple ''operator/use'' action.
Class E	One or more functions of a device/ system d not perform as designed during and after the test and cannot be returned to proper operation without repairing or replacing the device/ system. Note: It is of vital importance to pay attention to the chosen function status class, when evaluating tests and test results.

Note:

All electrical systems in the car shall have functional status class A , within the supply voltage range 10,5-16 V , functional status class B within the supply voltage range 9-10.5 V and functional status class C within the supply voltage range 0-9 V.

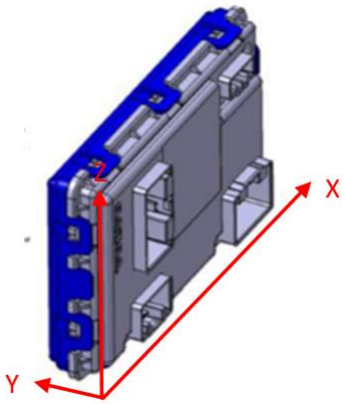
1) Systems that are vital for driving the car in a safe manner (Functional Importance Class C) shall have full function, defined as functional status class A, within the supply voltage range 9-16 V,

2) Information network systems in the car shall have functional status class A within the supply voltage range 8-16 V.

3) Systems needed to drive the car with reduced functionality shall have functional status class B within the supply voltage range 6-9 V.

1.9. DRAWING

1.9.1 DUT TEST POSITION



1.9.2. MECHANICAL VIEW

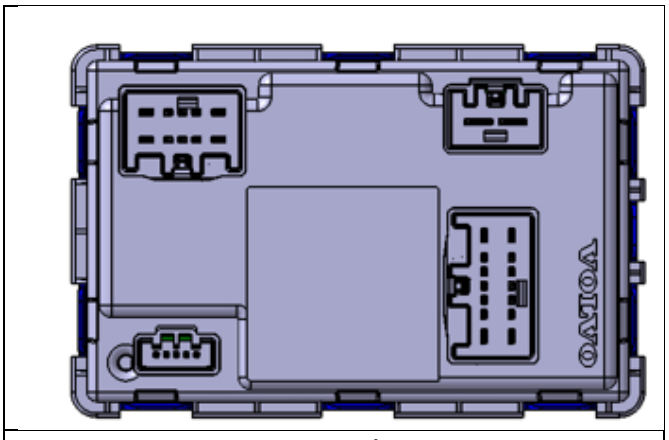
Housing material

The housing material will be PP T40 in black (non-metallic, non-conductive).

Dimensions

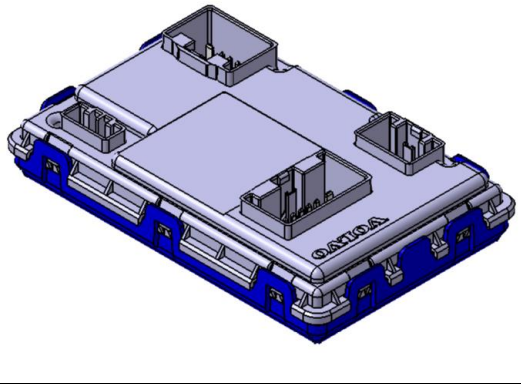
X × Y × Z = 142 x 31,45 x 92 mm

Mechanical construction - top view



RTU Variant

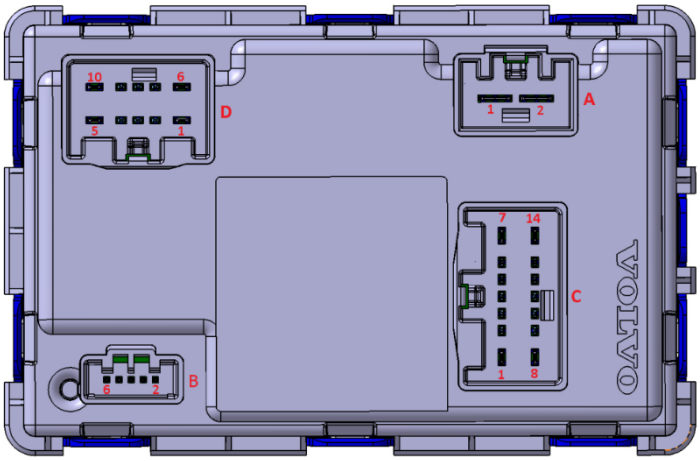
Mechanical construction - ISO view



RTU Variant

1.9.3. CONNECTORS ASSIGNMENT

Only RTU variant has all connectors populated; BASE variant has only connectors A, B and C present. Pin numbering and signal allocation is identical for both variants for A, B and C connectors except pin C10 valid only for RTU variant.



Connector A description

Pin	Direction	Description	Schematic label
A01	IN	Trailer Input Power Supply for Ignition Power output	TRLR_PWR_40
A02	IN	Trailer Input Power Supply for Permanent Power output	TRLR_PWR_20

Connector B description

Pin	Direction	Description	Schematic label
B01	-	Not mounted	-
B02	Comm.	CAN High Input	CAN_H
B03	Comm.	CAN Low Input	CAN_L
B04	Comm.	CAN High Output	CAN_H
B05	Comm.	CAN Low Output	CAN_L
B06	IN	Hardware Brake Input Signal	TRLR_HW_BRK_SIG
B07	-	Not mounted	-

Connector C description

Pin	Direction	Description	Schematic label
C01	IN	Power and signal ground	GND
C02	OUT	Reverse Light	RVS_LI
C03	IN	Digital Spare Input (not used by the application)	D_SPARE_IN
C04	OUT	Rear Right Position Light	RE_RI_POSNG_LI
C05(1)	OUT	Not Mounted	-
C06	OUT	Rear Left Position Light	RE_LE_POSNG_LI
C07	OUT	Trailer Ignition Power (KL_15) output	TRLR_IGN_PWR
C08	OUT	Rear Stop Light	RE_STOP_LI
C09	OUT	Rear Right Direction Indicator Light	RE_RI_DIR_INDCR_LI
C10	OUT	Safety Switch Common	SFTY_SWT_CMN
C11	OUT	Rear Left Direction Indicator Light	RE_LE_DIR_INDCR_LI
C12(1)	OUT	Spare high side driver	SPARE_HSD
C13	OUT	Rear Fog Light	RE_FOG_LI
C14	OUT	Trailer Permanent Power (KL_30) output	TRLR_PRMNT_PWR

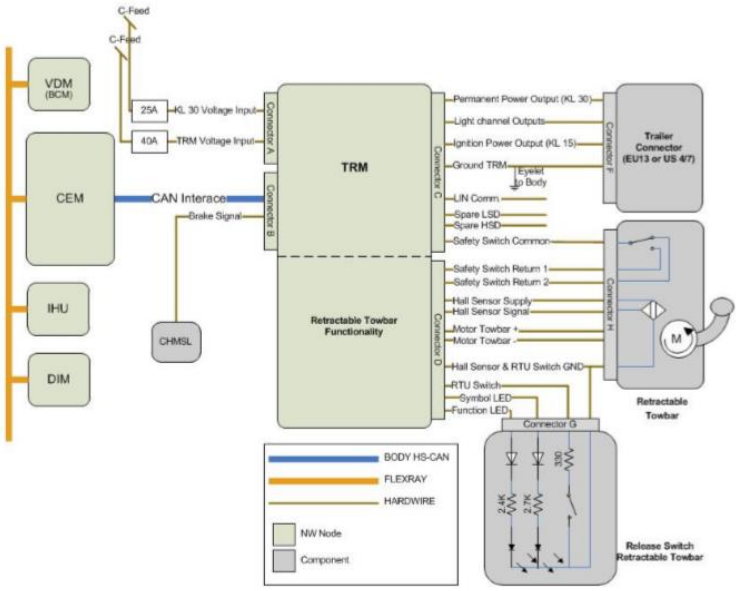
Notes:

(1) – Spare functionalities are not used by actual application; only populated pins and layout prepared.

Connector D description

Pin	Direction	Description	Schematic label
D01	OUT	Motor Tow bar Release Positive	MOT_TWBR_RELS_POS
D02	OUT	Illumination Switch Led	ILLMN_SWT_LED
D03	OUT	Lock Switch Led	LOCK_SWT_LED
D04	IN	Motor Position Sensor	MOT_POSN_SNSR
D05	OUT	Motor Position Sensor Ground	MOT_POSN_SNSR_GND
D06	OUT	Motor Tow bar Release Negative	MOT_TWBR_RELS_NEG
D07	IN	Safety Switch Normal Open	SFTY_SWT_NORM_OPEN
D08	IN	Safety Switch Normal Close	SFTY_SWT_NORM_CLS
D09	IN	Tow bar Release Switch	TWBR_RELS_SWT
D10	OUT	Motor Position Sensor Supply	MOT_POSN_SNSR_SPLY

1.9.4. BLOCK DIAGRAM



The TRM shall be able to handle different types of car-trailer connectors. The variants shall be controlled by a CarConfig parameters.

Parameter Trailer Module:

- without Trailer Module
- Trailer Module 13-pos socket
- Trailer Module 4/7-pos pocket

Parameter Retractable towbar functionality:

- Without retractable towbar
- Semi-electrical retractable towbar
- Fully-electrical retractable towbar

Both semi-electrical and fully electric retractable towbar will be implemented. Fully electric towbar will be developed and implemented for the first time.

The purpose of the Volvo SPA2 Trailer Module project is to develop one ECU (hardware, software and mechanical) which shall be mounted on the trunk of Volvo SPA2 car platforms, being designed for the customer Volvo Car Company. Scope of this project is to develop and validate hardware and software of Trailer module ECU as well as establish and run serial production of developed ECU.

The SW and Bootloader is based on the Continental AutoSar SW Platform (SWP) for the Cypress Traveo II processor.

Trailer related functionalities:

- communication over CAN; routed CAN bus output assured;
- 7 light channels handled (1xSTOP, 2xFlashing, 2xPositions, Fog and Reverse)
- one switched supply output (battery charge output) up to 20A;
- KL30 switched output up to 20A;
- HW brake input (redundant circuit for Break Lights handling) with wake-up capabilities;

Towing Ability: Handling of the retractable tow bar.

- **Tow bar Maneuvering:** Electrical maneuvering of the Tow bar. The position of the tow bar is monitored.
- **Tow bar Warning**: The driver is alerted if the tow bar is in an unlocked position.
- **Trailer/Caravan functions:** Preparation for trailer connection.

2. PARAMETRIC TESTS

The parametric test provides a complete assessment of the ECU's health and evaluates the functional characteristic of DUTs in accordance with Life time test (LTT).

Before starting the environment test, the DUT's shall pass the preceding Function test (as indicated in test flow) and may not show any mechanical damage on the visual inspection.

2.1 INITIAL PERFORMANCE TEST (Functional 2)

Electrical Parameters:

Electrical function test, all functions and test cycle, with test voltage and temperatures. Mechanical function check according to Test Cycle described below. ECU is tested at three temperatures (RT- room temperature, Tmin - low temperature and Tmax- high temperature) and at three supplies voltage ranges according with table below:

Temperature (°C)	T_{min} (-40°C)	RT (23 ±5)°C	T_{max} (+85°C)
Voltage (V)	U_{min} = (9±0,1) V	-	U_{min} = (9±0,1) V
	-	U_{nom} = (14±0,1) V	-
	U_{max} =(16±0,1) V	-	U_{max} =(16±0,1) V

Visual Inspection:

- Check samples for deformation (bending of the housing, twist of the housing and dents in the housings);
- Check housings for damages like scratches, cracks and color changes;
- Shake samples to check for loose parts inside the housing;
- Check label on the housing (prints and adhesion);
- Check connector pins, latches of plastic lid.

For more details, see Parametric Tests Specification for Volvo: (no. 33718830 rev. 006 Preliminary)

Visual inspection: Before and after all test a visual inspection of the DUT shall be performed (without opening the housing);

For more details, see VCC Supplement to ISO16750:31822854, revision 015, vol. 01(Chapter 7.3- Visual inspection).

2.2 FUNCTIONAL TESTS (Functional 1)

The parameter test shall be done between successive tests (see test flow plan).

- **Electrical Parameters:**

The key parameters shall be measured and the functional behavior of the components checked at T_{RT} and U_{nom}.

Temperature (°C)	Power Supply (V)
T_{RT}	U_{nom} = 14±0,1V

Visual Inspection:

- Check samples for deformation (bending of the housing, twist of the housing and dents in the housings);
- Check housings for damages like scratches, cracks and color changes;
- Shake samples to check for loose parts inside the housing;
- Check label on the housing (prints and adhesion);
- Check connector pins, latches of plastic lid.

2.3. FINAL PERFORMANCE TEST (Functional test 2)

- The final performance test is identical to the initial performance test.

3. HIGH TEMPERATURE STORAGE TEST

Purpose:

This test simulates the exposure of the DUT to high temperatures without electrical operation, e.g. during the shipment of the system/component. Failure mode is insufficient heat resistance, e.g. the warping of plastic housings.

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-2 Test B: Dry heat (2007-07);

Test Parameters:

Total test duration	504 h + ramp time
Test duration (t_1)	504 h
Maximum Temperature (T_{max})	+85°C
Rate of Temperature Change (T_{Change})	≤1K/min
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	Not relevant
Operating Mode	1.1
Functional status classification	A (after functional test 1)
Number of samples	6

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and must not show any mechanical damage on the visual inspection.

Test Procedure:

A. Place the DUTs (DUT temperature is RT) in the temperature chamber at temperature RT;
B. The temperature in the chamber shall then be adjusted to the temperature T_{max} at a rate of temperature change T_{Change};
C. Maintain the DUTs at temperature T_{max} for the time t_1. The duration shall be measured from the time when the temperature stability of the chamber is reached;
D. At the end of this period, the DUTs shall remain in the chamber and the temperature shall be gradually lower at a rate of temperature change T_{Change} to a value lying within the limits of the standard atmospheric conditions for measurements and testing.
E. Remove the DUTs from the chamber.
F. The DUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 1h.

Acceptance Criteria:

The DUTs shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

4. TEMPERATURE CYCLING WITH SPECIFIED TEMPERATURE CHANGE RATE TEST

Purpose:

This test determines the ability of components, equipment or other articles to withstand and/or function during changes of ambient temperature.

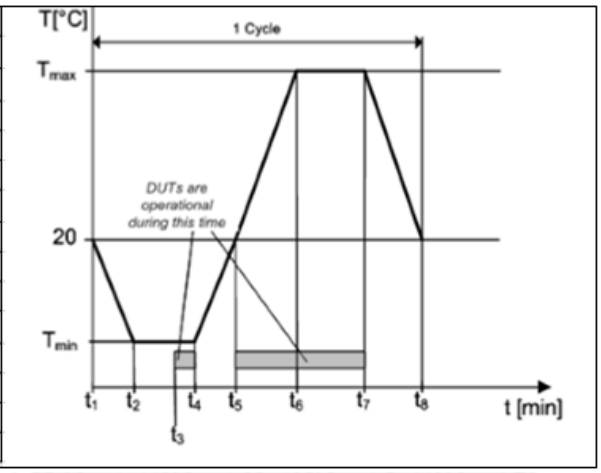
Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-14 Test Nb: Change of temperature (2009-01);

Test Parameters:

Total test duration	240h
Number of cycle	30
Test Cycle duration (N_{Cycle})	8 h
Minimum Temperature (T_{min})	-40°C
Maximum Temperature (T_{max})	+85°C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT test position	According to Ch. 1.9.1
Operating mode	1.2/3.3
Functional status classification	1.2 – class C 3.3 – class A
Number of samples	6

Temperature and Electrical Operation Profile:

t (min)		T (°C)
t_1	0	20
t_2	60	Tmin
t3	140	Tmin
t4	150	Tmin
t5	210	20
t_6	300	Tmax
t7	410	Tmax
t8	480	20
Operating mode		
t_1 to t3		1.2
t3 to t4		3.3
t4 to t5		1.2
t5 to t7		3.3
t7 to t8		1.2



Maximum Temperature Gradient [K/min]: 85 °C = 1, 110°C = 1,25, 125°C = 1,5, 140°C = 1,71

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test procedure:

A. At the beginning of the test the DUT shall be at the ambient temperature of the laboratory.
B. Place the DUT in the temperature chamber at temperature 20ºC.
C. Subject and operate the DUT to N_{Cycle} between temperature T_{min} and T_{max} according to the ''Temperature and electrical operation profile'' above.
D. The DUTs shall then remain under standard atmospheric conditions for the attainment of temperature stability.

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

5. RAPID CHANGE OF TEMPERATURE WITH SPECIFIED TRANSITION DURATION TEST

Purpose:

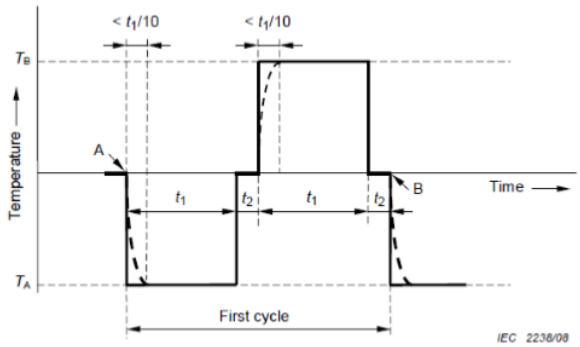
This test determines the ability of components, equipment or other articles to withstand rapid changes of ambient temperature. The exposure times adequate to accomplish this will depend upon the nature of the specimen.

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-14 Test Na: Change of temperature (2009-01);

Test Parameters:

Total test duration	~11 days
Number of Test Cycle (N_{Cycle})	200
Minimum Chamber Temperature (T_{min}= T_A)	-40°C
Maximum Chamber Temperature (T_{max}= T_B)	+85°C
Holding Time (t_1, t_3) at T_{max}, T_{min}	1h after equilibrium time (+15min) => 75 min
Equilibrium time	15 min
Transfer Time (t_2) between Chambers	<10s
DUT Test Position	Not relevant
Operating Mode	1.1
Functional status classification	A (after functional test 1)
Number of samples	6

Temperature Cycle Profile:



Key:
A start of first cycle
B end of first cycle and start of second cycle

Initial Evaluation of Test:

Before starting the environment test the DUT's shall pass the preceding function test (as indicated by the test flow) and must not show any mechanical damage on the visual inspection.

Test Procedure:

A. At the beginning of the test the DUT shall be at the ambient temperature of the laboratory.

B. Place the DUTs in a dual zone thermal shock chamber and adjust the temperature to zones to T_A and T_B.

C. Maintain the DUTs at temperature T_A for the time t_1.

D. Transfer the DUTs from the T_A zone to the T_B zone within t_2.

E. Maintain the DUTs at temperature T_B for the time t_1. F. Transfer the DUT's from the T_B zone to the T_A zone within t_2.

G. Repeat the thermal cycles (steps B through F) for a total number of N_{Cycle}.

H. The DUT's shall then remain under standard atmospheric conditions for the attainment of temperature stability.

Acceptance Criteria:

The DUTs shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

6. RANDOM AND SINUSOIDAL VIBRATIONS AND TEMPERATURE CYCLING TEST

Purpose:

This test simulates the vibration load of the component during driving operation. The test serves to verify the resistance of the part to faults, such as component displacement or material fatigue.

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-3: (2012-12-15);
ISO 16750-4- (2010-04-15);
IEC 60068-2-64 (2019-10);
IEC 60068-2-14 Test Nb: Change of temperature (2009-01);

Note:

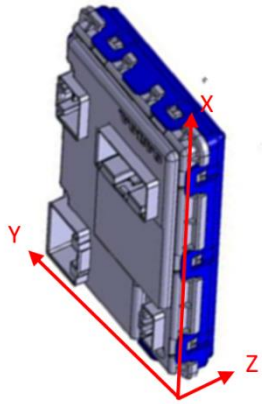
In order to reduce setup time, the vibration test will be done in the following way: you can first run sinus in x direction, then random in x direction, after that reposition the DUT to next direction and repeat the procedure sinus and random then reposition to the third direction and repeat.

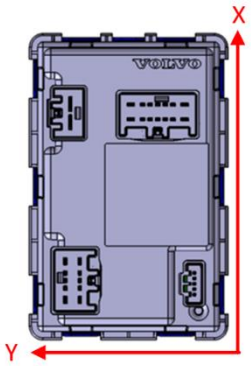
6.1. SINUSOIDAL VIBRATION

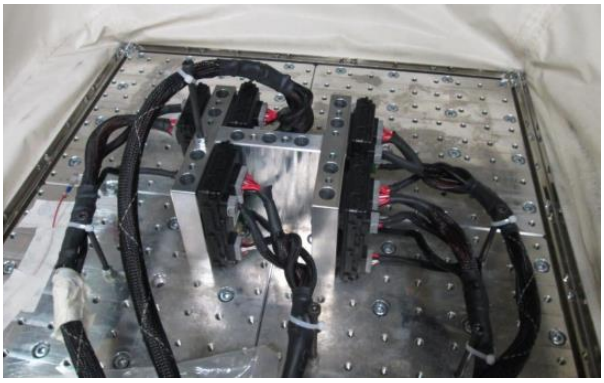
Test Parameters for Sinus Vibration:

Test Cycle Duration	1 h x, y axis 3 h z axis
Number of Test Cycle (N_{cycle})	1 cycle each axis
Sweep rate	1 Oct/min.
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see picture below)
Operation/Monitoring Mode	3.3
Functional Status Class	A
Number of samples	6

Vibration DUT test position







Sinusoidal Vibration profile:

Amplitude 5-10 Hz: 10.0 mm
Amplitude 10-60 Hz: 40 m/s²
Amplitude 60-200 Hz: 20 m/s²

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A cable harness true to the original cable harness in the vehicle has to be used (same cable width like in the vehicle; no additional cables in the harness are allowed). The mechanical support of the cable harness has to be on the vibration fixture. Vibration control is on the vibration fixture. Demonstrative acoustical behavior (noise, rattling) has to be documented.

A. Place the DUT on a vibration fixture on in mounting position.
B. The cable harness has to be reinforced (fixed) in a distance of (15 ± 2) cm to the connector.
C. Operate the DUT electrically and perform Sinusoidal Vibration according to the above vibration profile at RT.
D. At the end of test cycle for this axis, repeat steps A and C for the remaining two axes.

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

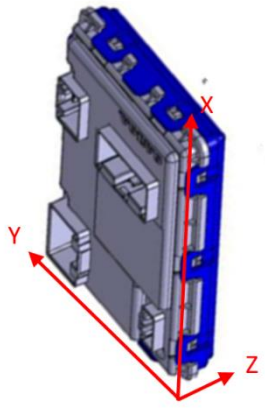
In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

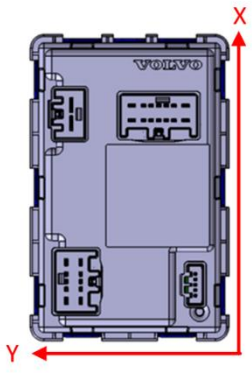
6.2. RANDOM VIBRATION

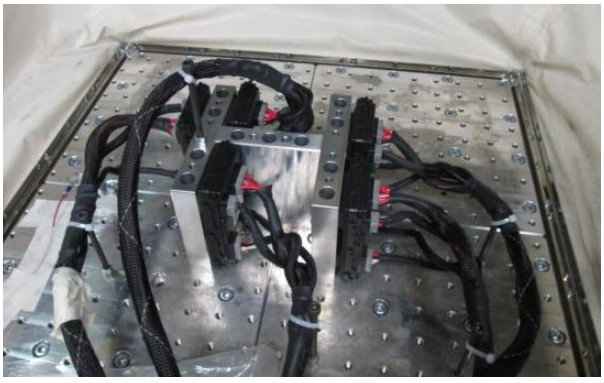
Test Parameters for Random Vibration:

Total Test Duration	8 h x, y axis 32 h z axis
Number of Vibration Test Cycles (NCycle)	1 cycle each axis
Maximum Temperature (Tmax)	-40°C
Maximum Temperature (Tmin)	85°C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operation/Monitoring Mode	3.1/3.2
Functional Status Class	3.1- class C 3.2- class A
Number of samples	6

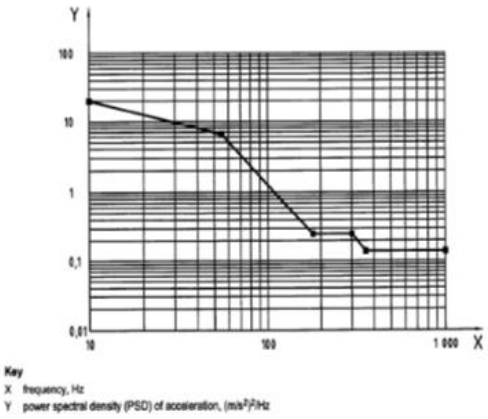
Vibration DUT test position







Random Vibration profile:

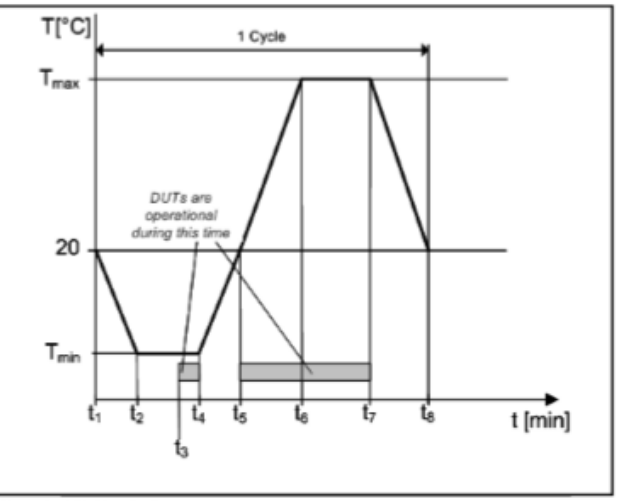


Frequency Hz	PSD $(m/s^2)^2/Hz$
10	20
55	6,5
180	0,25
300	0,25
360	0,14
1 000	0,14

RMS acceleration: 27,8 m/s²

Temperature and Electrical Operation Profile for Random Vibration test:

t (min)		T (°C)
t_1	0	20
t_2	60	T_{min}
t_3	140	T_{min}
t_4	150	T_{min}
t_5	210	20
t_6	300	T_{max}
t_7	410	T_{max}
t_8	480	20
Operation mode		
t_1 to t_3		3.1
t_3 to t_4		3.2
t_4 to t_5		3.1
t_5 to t_7		3.2
t_7 to t_8		3.1



Maximum Temperature Gradient 1[K/min]

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A cable harness true to the original cable harness in the vehicle has to be used (same cable width like in the vehicle; no additional cables in the harness are allowed). The mechanical support of the cable harness has to be on the vibration fixture. Vibration control is on the vibration fixture. Demonstrative acoustical behavior (noise, rattling) has to be documented.

A. Place the DUT on a vibration fixture according to the "Vibration DUT test position".
B. The cable harness has to be reinforced (fixed) in a distance of (15 ± 2) cm to the connector.
C. Operate the DUT electrically according to the temperature and electrical operation profile above.
D. At the end of test cycle for this axis, repeat steps A and C for the remaining two axes.

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

7. COMPOSITE TEMPERATURE/ HUMIDITY CYCLE TEST

Purpose:

The test simulates the use of a system/component under high ambient humidity. The failure modes addressed are electrical malfunctions caused by moisture, for example from leakage current caused by a printed circuit board soaked with moisture.

An additional failure mode is a "breathing effect" that transports moisture inside the housing when the air inside the DUT cools down and ambient air with high humidity is drawn into it.

An additional failure mode is the transport of corrosive additives used in the plastic material to the material surface that can cause corrosion on metallic parts and PCB's used in the DUT. An example of a corrosive halogen is Potassium-Iodide commonly used as temperature stabilizer in PolyAmide (PA).

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-38, Test Z/AD (2009);

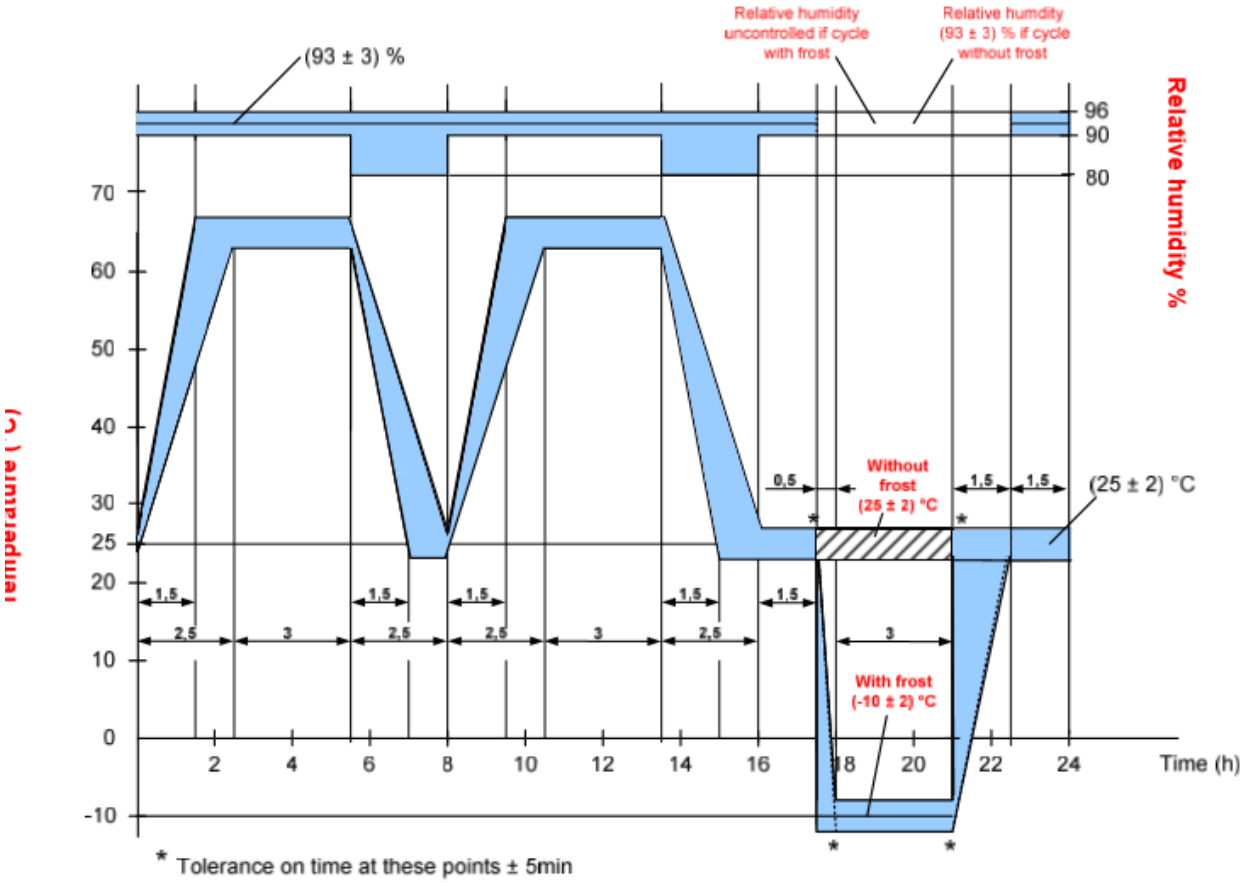
Deviation:

Pre-conditioning for ''assisted drying'' it's not applicable.

Test Parameters:

Total Test Duration	240 h (10 days)
Test Cycle Duration	24 h
Number of Test Cycle (Ncycle)	10
Maximum Temperature (Tmax)	(65 ± 2) °C
Minimum Temperature (Tmin)	(-10 ± 2) °C
Relative Humidity (RH1)	See humidity cycle below
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operating mode	with electrical operation 2.1/ 3.3 3.3 – (during 15 minutes beginning at the start of each transition from max temperature period and 5 minutes at the end of min temperature period.)
Functional Status Class	2.1- class C 3.3- class A
Number of samples	6

Humidity Cycle:



Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. Adjust a climatic chamber to a temperature (25 ± 2) °C and relative humidity (93 ± 3) RH.

B. Place the DUT (DUT temperature is RT) in the climatic chamber.

C. Perform N cycles of the humidity cycle according to the graph above. Alternate cycle with and without frost (odd cycle with frost).

D. Perform a functional check (in accordance to the operation mode).

E. On completion of the final cycle, the specimen shall be removed from the chamber and shall be kept under standard atmospheric conditions for testing for a period of 24 h before the specified functional test 1 (as indicated in the test flow plan) are made.

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

8. DAMP HEAT, STEADY STATE TEST

Purpose:

The test simulates the use of a system/component under high ambient humidity. Failure mode is electrical malfunctions caused by moisture (e.g. leakage current caused by a printed circuit board which is soaked with moisture).

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-78 (2012-10);

Deviations:

Thermal stabilization time is not taken into account. There will be no influence of test result if the temperature stabilization time is short compared with the duration of the exposure.

Test Parameters:

Total Test duration	21 days (504h)
Test temperature	40 ±2°C
Test humidity	93 % ±3% relative humidity
DUT Test Position	Not relevant
Operation/Monitoring Mode	2.1/3.3 (1minute/hour)
Functional status classification	A
Number of samples	6

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. Place the DUT (DUT temperature is RT) in the climatic chamber;
B. Adjust a climatic chamber to a temperature (40) °C and relative humidity (93 ± 3) RH;
C. Perform the test according to the table above with operation mode 2.1 and 3.3 during 1 minute once per hour, last minute of each hour.
D. The DUTs shall then remain under standard atmospheric conditions for recovery for the attainment of temperature stability.

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

9. LOW TEMPERATURE STORAGE TEST

Purpose:

This test simulates the exposure of the DUT to low temperatures without electrical operation, e.g. during shipment of the system/component. Failure mode is insufficient frost resistance, e.g. the freezing of liquid crystal displays.

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-1 Test A: Cold(2007-07);

Test Parameters:

Total test duration	24 h + ramp time
Test duration (t_1)	24 h
Minimum Temperature (Tmin)	-40°C
Rate of Temperature Change (T_{Change})	≤1K/min (average over a period of not more than 5 min)
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	Not relevant
Operating Mode	1.1
Functional status classification	A (after functional test 1)
Number of samples	6

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and must not show any mechanical damage on the visual inspection.

Test Procedure:

A. Place the DUTs (DUT temperature is RT) in the temperature chamber at temperature RT.
B. The temperature within the chamber shall then be adjusted to the temperature Tmin at a rate of temperature change T_{Change}.
C. Maintain the DUTs at temperature T_{min} for the time t1. The duration shall be measured form the time when the temperature T_{min} is reached.
D. At the end of this period, the DUTs shall remain in the chamber and the temperature shall be gradually raised at a rate of temperature change T_{Change} to a value lying within the limits of the standard atmospheric conditions for measurement and testing.
E. Remove the DUTs from the chamber.

F. The DUTs shall remain under standard atmospheric conditions until temperature stability is reached.
G. To remove droplets of water, the DUT may be shaken by hand or a blast of air at laboratory temperature may be applied for a short time
H. The DUTs shall then remain under standard atmospheric conditions for recovery for a minimum of 1h.

Acceptance Criteria:

The DUTs shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

10. LOW TEMPERATURE OPERATION TEST

Purpose:

This test simulates the exposure of a system/component to low temperatures with electrical operation, for example use at very low ambient temperature. Failure mode is electrical malfunction caused by low temperature (e.g. freezing of capacitors with liquid electrolyte).

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-2 Test B: Dry heat (2007-07);

Deviation:

Thermal stabilization time is not taken into account. There will be no influence of test result if the temperature stabilization time is short compared with the duration of the exposure (Assumption: temperature stabilization time ≤ 1/10 of total test duration).

Test Parameters:

Total Test Duration at T_{min}	24h + ramp time
Rate of Temperature Change (T_{Change})	1 K/min (average over a period of not more than 5 min)
Minimum Temperature (T_{min})	-40°C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operating Mode	3.3
Functional status classification	A
Number of samples	6

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. Place the DUTs (DUT temperature is room temperature) in the temperature chamber at room temperature;
B. The temperature within the chamber shall then be adjusted to temperature T_{min} at a rate of temperature change T_{Change} ;

C. Maintain and operate the DUTs at temperature T_{min} for 24h. The duration shall be measured form the time when the temperature T_{min} is reached;
D. At the end of this period, the specimen shall remain in the chamber and the temperature shall be gradually raised at a rate of temperature change T_{Change} to a value which is within the limits of the standard atmospheric conditions for measurement and testing;
E. Remove the DUTs from the chamber;
F. To remove droplets of water, the DUT may be shaken by hand or a blast of air at laboratory temperature may be applied for a short time;
G. Before any other test, the DUTs shall then remain under standard atmospheric conditions for recovery for at least 1h.

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

11. HIGH TEMPERATURE OPERATION TEST

Purpose:

This test simulates the exposure of a system/component to high temperatures with electrical operation, for example use at very high ambient temperature. Failure mode is electrical malfunction caused by high temperature (e.g. thermal degradation of components).

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);
IEC 60068-2-2 Test B: Dry heat (2007-07);

Test Parameters:

Total Test Duration at T_{max}	24h + ramp time
Rate of Temperature Change (T_{Change})	1 K/min (average over a period of not more than 5 min)
Minimum Temperature (T_{max})	+85 °C
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operating Mode	3.4
Functional status classification	A
Number of samples	6

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

a. Place the DUTs (DUT temperature is room temperature) in the temperature chamber at room temperature;
b. The temperature within the chamber shall then be adjusted to temperature T_{max} at a rate of temperature change T_{Change} ;
c. Maintain and operate the DUTs at temperature T_{max} for 24h. The duration shall be measured form the time when the temperature T_{min} is reached;
d. At the end of this period, the specimen shall remain in the chamber and the temperature shall be gradually lower at a rate of temperature change T_{Change} to a value which is within the limits of the standard atmospheric conditions for measurement and testing;
e. Remove the DUTs from the chamber;

f. To remove droplets of water, the DUT may be shaken by hand or a blast of air at laboratory temperature may be applied for a short time;
g. Before any other test, the DUTs shall then remain under standard atmospheric conditions for recovery for at least 1h.

Acceptance Criteria:

The DUTs shall be fully functional before,during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

12. TEMPERATURE STEP TEST

Purpose:

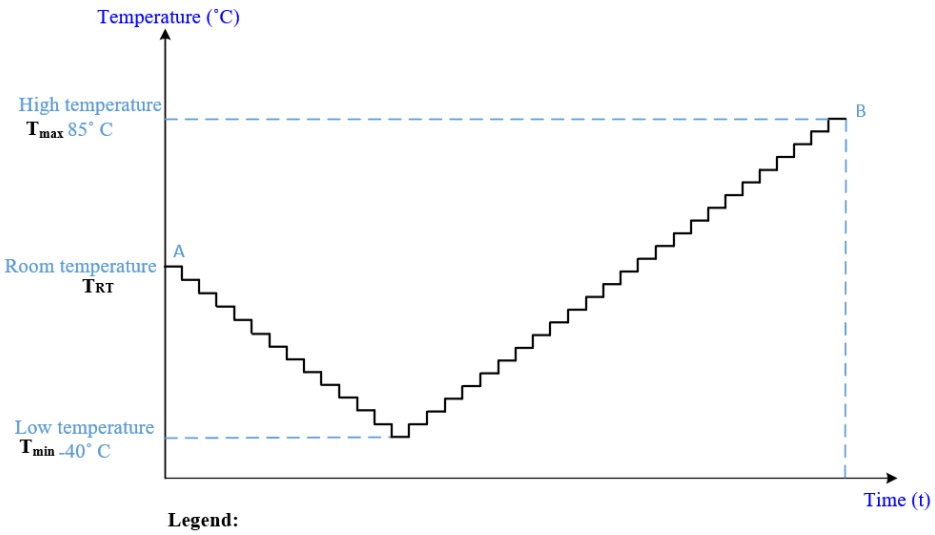
This test checks the mechanical and electrical device for malfunctions which may occur within a small section of the operating temperature range.

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-4- (2010-04-15);

Test Parameters:

Number of Test Cycle (N_{Cycle})	1
Minimum Temperature (T_{min})	-40°C
Maximum Temperature (T_{max})	+85°C
Temperature step	5°C
Holding Time at each step	30 min (15 min for temperature stabilization and 15 minutes for functional test)
Rate of Temperature Change (T_{Change})	1 K/min (average over a period of not more than 5 min)
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operating mode	1.2/3.3
Functional status classification	A
Number of samples	6

Temperature Profile:



Legend:
A: Beginning of first cycle;
B: End of cycle
T temperature, in °C
t time, in min

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test procedure:

A. Place the DUT in the temperature chamber and stabilize the temperature at RT;
B. Decrease the temperature in steps of 5 °C from RT to T_{min} and then increase the temperature in steps of 5°C from T_{min} to T_{max}. Wait at each step, until the DUT has reached the new temperature. Perform a function test using operation mode 3.3 at each temperature step. Between the temperature steps the DUT shall not be operated (1.2);
C. Return the DUT to room temperature (RT).

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

13. MECHANICAL SHOCK TEST

Purpose:

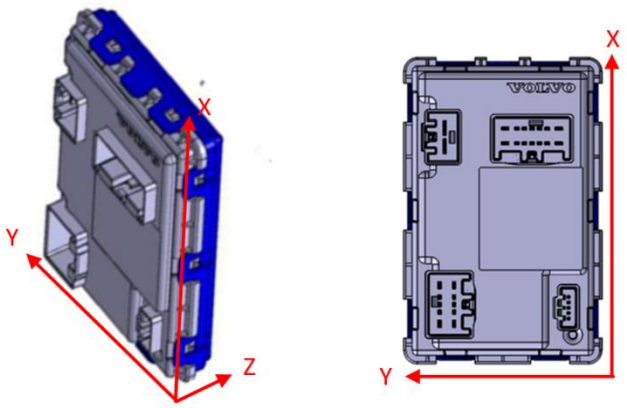
This test checks the DUT for malfunctions and breakage caused by shock to body and frame. The load occurs when driving over a curb stone at high speed, etc. Failure mode is mechanical damage (e.g. a detached capacitor inside the housing of an electronic control module due to the occurring high accelerations).

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-3: (2012-12-15);
IEC 60068-2-27(2008);

Test Parameters:

Pulse Shape	Half-sine
Shock Pulse Duration	6 ms
Peak acceleration	500 m/s²
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	See pictures below
Operating Mode	3.2
Functional status classification	A
Number of samples	6

Mechanical shock DUT test position:



Temperature and Number of Shocks per Direction:

Temperature	Mechanical Shocks Each Direction					
RT	+X	-X	+Y	-Y	+Z	-Z
	10	10	10	10	10	10

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A cable harness true to the original cable harness in the vehicle has to be used (same cable width like in the vehicle); no additional cables in the harness are allowed.
The mechanical support of the cable harness has to be on the vibration fixture.
Vibration/pulse control is on the vibration fixture.
Demonstrative acoustical behavior (noise, rattling) has to be documented.

A. The DUT shall be fixed on the shaker in a direction to generate the effect of acceleration in the same direction as it occurs in the vehicle use. Acceleration resulting from the shock in the test shall be in the same direction as the acceleration of the shock that occurs in the vehicle.
B. The cable harness has to be reinforced (fixed) in a distance of (15 ± 2) cm to the connector.
C. Apply a half-sine shock pulse (number of shocks, direction and test temperature as indicated in tables above).

Acceptance Criteria:

The DUTs shall be fully functional before, during and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

14. DROP TEST

Purpose:

A system/component could drop to the floor during handling (e.g. at the manufacturing line of the car manufacturer). If a system/component is visibly damaged after a fall, it will be replaced. But if it is not visibly damaged, after a fall, it will be installed in the car and then must work correctly. Failure mode is mechanical damage (e.g. a detached capacitor inside the housing of an electronic control module due to the high accelerations when the DUT hits the ground).

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 16750-3: (2012-12-15);
IEC 60068-2-31(2008);

Test Parameters:

Drop Height	1 m
Drop Directions, Drop Numbers	See table below
Impact Surface	Concrete ground
Test Temperature (T)	RT
Relative humidity	25 % to 75 %.
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	See directions and numbers below
Operating Mode	1.1
Functional status classification	A (after functional test 1)
Number of samples	6

Drop Directions and Numbers: For more sample: must be clarified the drop directions with project team.

DUT	**Drop directions**	
	1st drop	**2nd drop**
1st DUT	+X	-X
2nd DUT	+Y	-Y
3rd DUT	+Z	-Z
4th DUT	+X	-X
5th DUT	+Y	-Y
6th DUT	+Z	-Z

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. The DUTs are to be dropped according the parameters given above;
B. Visually inspect the DUTs for any obvious damage visible to the naked eye. Any and all damage noted following each drop must be fully documented with pictures, clearly noting the axis in which the damage occurred (refer to the definition of Axes section).

Acceptance Criteria:

Hidden damage is not permitted.
Minor damage of the housing is permitted as long as this does not affect the performance of the DUT.

The DUT shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

If the DUT is visibly damaged, all incidents of damage shall be documented in the test report.

15. CONNECTOR PINS PUSH/PULL TEST

Purpose: Evaluates DUT capability to withstand pressure/pulling force on the pins.

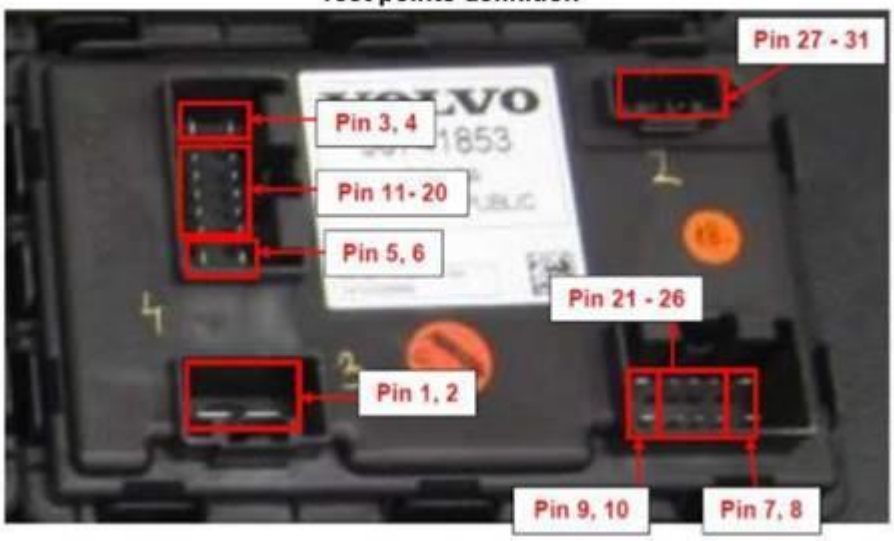
Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);

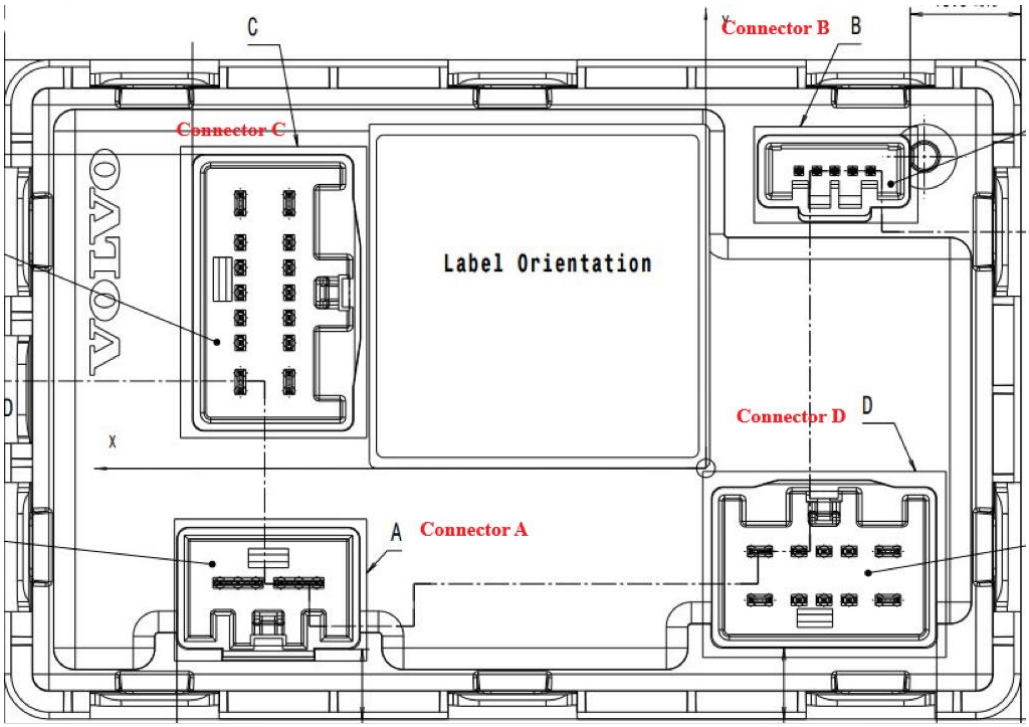
Test Parameters:
The pushing and pulling force shall be according to the table below:

Size of terminal [mm]	Force [N]
6.3	75
2.8	60
1.5	30
0.64	12

TRM connectors shall be positioned somewhere that let the PCB has the maximum coating surface.

Test points definition





Size of connector A:

Pin		Type	Description
Connector 7283-6458-40A pinning	1	6.3mm x 0,8mm	Trailer Input Power and Ignition Power
	2	6.3mm x 0,8mm	Trailer Input Permanent Power

Size of connector B:

Pin		Type	Description
Connector JAE IL-AG5-7P-S3T2 pinning	1	NOT POPULATED	-
	2	0,64mm x 0,64mm	CAN High Input
	3	0,64mm x 0,64mm	CAN Low Input
	4	0,64mm x 0,64mm	CAN High Output
	5	0,64mm x 0,64mm	CAN Low Output
	6	0,64mm x 0,64mm	Hardware Brake Signal
	7	NOT POPULATED	-

Size of connector C:

Pin		Type	Description
Connector 7283-6447-40A pinning	1	2,8mm x 0,8mm	InpGnd
	2	1,5mm x 0,8mm	RvsLi
	3	1,5mm x 0,8mm	ComPort
	4	1,5mm x 0,8mm	ReRiPosngLi
	5	1,5mm x 0,8mm	SpareLoSideDrv
	6	1,5mm x 0,8mm	ReLePosgnLi
	7	2,8mm x 0,8mm	TrlrIgnPwr
	8	2,8mm x 0,8mm	ReStopLi
	9	1,5mm x 0,8mm	ReRiDirIndcrLi
	10	1,5mm x 0,8mm	SftySwtCmn
	11	1,5mm x 0,8mm	ReLeDirIndcrLi
	12	1,5mm x 0,8mm	SpareHiSideDrv
	13	1,5mm x 0,8mm	ReFogLi
	14	2,8mm x 0,8mm	TrlrPrmntPwr

Size of connector D:

Pin		Type	Description
Connector 7283-6459-40A pinning	1	2,8mm x 0,8mm	MotTwbrRelsPos
	2	1,5mm x 0,8mm	IllmnSwtLed
	3	1,5mm x 0,8mm	LockSwtLed
	4	1,5mm x 0,8mm	MotPosnSnsr
	5	2,8mm x 0,8mm	MotPosnSnsrGnd
	6	2,8mm x 0,8mm	MotPosnSnsrGnd
	7	1,5mm x 0,8mm	SftySwtNormOpen
	8	1,5mm x 0,8mm	StySwtNormCls
	9	1,5mm x 0,8mm	TwbrRelsSwt
	10	2,8mm x 0,8mm	MotPosnSnsrSply

a) Pressure force on the connector (each pin connector):

Velocity	10-50mm/min
Test duration:	3 sec. after the full force is reached the test is stopped.

b) Pulling force on the connector (each pin connector):

Velocity	10-50mm/min
Test duration:	3 sec. after the full force is reached the test is stopped.

Ambient temperature during testing:	RT
Operation mode:	1.1
Functional Status Class	N.A

Initial evaluation:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Acceptance Criteria:

Connector terminal pins must withstand a force applied smoothly in an axial direction with a velocity of 10-50mm/min. After the tests there shall be no deformation, bending or loss of function in any kind.

16. CHEMICAL LOADS TEST

Purpose:

The purpose of the test is to determine whether the device under test (DUT) is unacceptably affected by temporary exposure to contaminating agents.

Applicable Standard: Note DPR 33718830- 005 (2019-09-19);
ISO 16750- 5 (2010-04-15);

Test Parameters:

Apply Temperature for Chemicals	RT
Storage Time (t_1) at T	Mentioned in table below
Temperature Reference Point	Ambient temperature (chamber temperature)
DUT Test Position	In-vehicle mounting orientation (see chapter drawing)
Operation/Monitoring Mode	1.1
Functional status classification	A (after functional test)
Number of samples	8

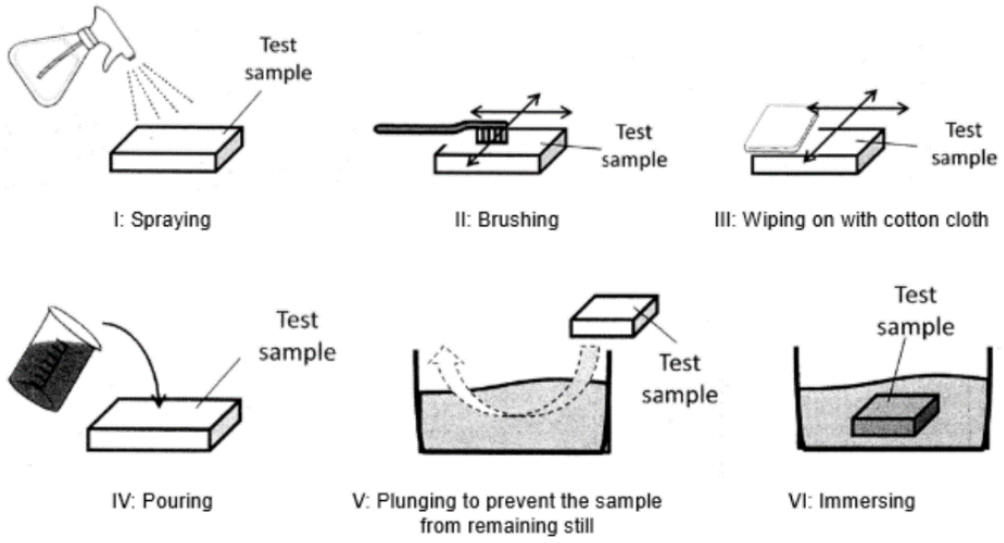
Note 1: This test is not intended to be a life test.
Note 2: Safety instructions and warnings for the chemicals shall be observed.
Note 3: The chemicals must not be applied over the connectors' area.

DUT	Groups	ID	Chemical agents	Test Temperature	Test duration	Description of active substance
1	Fuels	AD	Kerosene	RT	10 min	See ASTM D 1655b
2	Other operating agent	CA	Battery Fluid	RT	22 h	37 % H2SO4
3	Cleaning agents	DA	Windscreen Washer	RT	2 h	5 % anionic tenside, deionized water
4	Cleaning agents	DC	Interior Cleaner	RT	2 h	e.g. Motip Cockpit Spray™g
5	Cleaning agents	DD	Glass Cleaner	RT	2 h	CAS 111-76-2
6	Cleaning agents	DF	Cold Cleaning Agent	RT	22 h	e.g. P3-Solvclean AK™ (supplied by Henkel)g
7	Cleaning agents	DJ	Amonium containing cleaner	RT	22 h	e.g. Ajax™ (supplied by Henkel)g
8	Cleaning agents	DK	Denaturated Alcohol	RT	10 min	CAS 64-17-5 (ethanol)

Application Method:

I	**Spray**	Spray the DUT with the chemical agent until it is completely wet. Let redundant agent drip off the DUT.
II	**Brushing**	Immerse brush into the chemical agent fore each new side. Brush the DUT until it is completely wet. Let redundant agent drip off the DUT.
III	**Wiping**	Wet a cotton cloth (30x30) with 50ml respective chemical agent. Wet the DUT with this cotton cloth until it is completely wet. Let redundant agent drip off the DUT.
IV	**Pouring**	According to the picture below.
V	**Dipping**	According to the picture below.
VI	**Immersing**	According to the picture below.

Explanatory notes: I: Spraying
II: Brushing
III: Wiping on with cotton cloth
IV: Pouring
V: Plunging to prevent the sample from remaining still
VI: Immersing
Tmax: Maximum ambient temperature



I: Spraying
II: Brushing
III: Wiping on with cotton cloth
IV: Pouring
V: Plunging to prevent the sample from remaining still
VI: Immersing

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

DUT conditioning

Unless otherwise specified, the DUT shall be stored at a room temperature (RT) of (23 ± 5) °C and a relative humidity (RH) of between 25 % and 75 % until temperature and humidity are stabilized.

Test agent conditioning

Unless otherwise specified, all test agents shall be stabilized at an RT of (23 ± 5) °C when applied on the DUT.

Test Procedure:

Use the DUT as defined in the table above for each chemical agent.

A. Apply chemical agents at RT, on the surface of the housing (test fluid and application method are indicated in the table above);
B. Store the DUTs in the climatic chamber for the time t_1 at the temperature T (storage temperature and time for each chemical agent/DUT are indicated in the table above);
C. Remove the chemical agents from the DUT surfaces using a dry tissue.

Acceptance Criteria:

The DUTs shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

17. PROTECTION AGAINST FOREIGN OBJECTS TEST

Purpose: Evaluates DUT protection level against foreign objects and against access.

Applicable Standard: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 20653 Degrees of protection IP code (2013-02-15);

Test Parameters:

Degree of protection:	IP 4X (≥ 1mm diameter)
Test equipment:	wire
Test force:	1N ± 10%
Sample-temperature:	R.T.
Operation mode (Test content in the test):	1.1
Functional Status Class	N.A
Number of samples	8

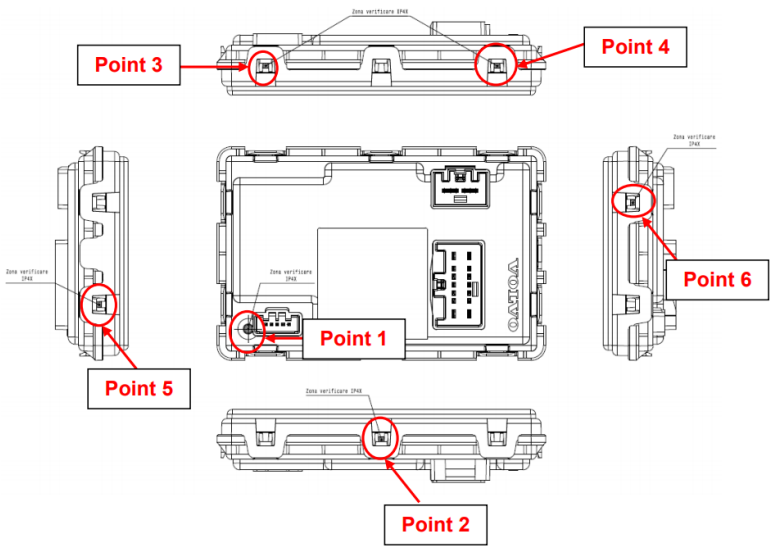
Initial evaluation of test:

Before starting the environmental test the samples shall pass the preceding Functional test and may not show any mechanical damage on the visual inspection.

Test Procedure:

A. Check using the test probe for protection of the DUT against access. For area of interest, see picture below.

Testing points definition:



Acceptance Criteria:

Wire (≥ 1 mm diameter) may not penetrate completely.

The DUTs shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

18. IP PROTECTION WATER INTRUSION (IP X2) TEST

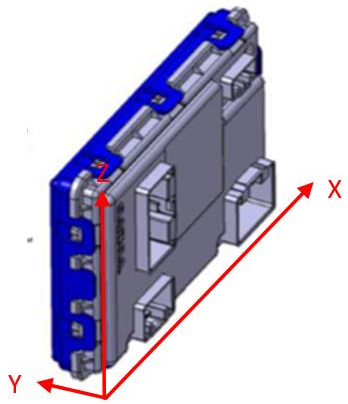
Purpose: Evaluates DUT protection level when exposed to water.

Applicable Standard: Note DPR 33718830- 005 (2019-09-19);
Note SPEC 31822854 – 015 (2019-07-09);
ISO 20653 Degrees of protection IP code (2013-02-15);

Test Parameters:

DUT Temperature (T_{DUT})		RT	
Test Equipment		200 mm from the very topmost component of DUT	
DUT Test Position		DUTs tested in the position with the connectors pointing straight up (see picture below)	
Operation/Monitoring Mode		1.2	
Functional Status Class		N/A	
Drip Water			
Water Temperature (T_{Water})		T_{DUT} ± 5 °C	
Water Flow Rate		(3,0 ± 0,5) mm/min (precipitation height)	
Number of samples		8	
Test Orientation Profile			
Test Position	15° Tilt about the	In the Direction of the	Test Duration (t1)
1	Y axis	+ X axis	2,5 min each position
2		-X axis	
3	X axis	+ Y axis	
4		-Y axis	

DUT test position:



Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

Connect original connectors to the DUT.

A. Adjust the flow rate of the drip water according the parameter given above
B. Each DUT shall be attached to the spray chamber turntable and tested in each of the (4) fixed position(s) of 15° tilt described above.
C. The drip box shall be positioned 200 mm from the very topmost component of the DUT.
D. Subject each DUT to a uniform flow of water drops (drip water) over the entire exposed surface area for the time t1. The turntable shall not rotate during test.
E. Repeat step B to D for the remaining test positions.

Do not open the DUT before performing the functional/parametric test.

Acceptance Criteria:

The DUTs shall be fully functional before and after the test and all parameters shall meet the specifications. Verification is done by means of a functional test 1 as per Section 2.2.

In addition, the DUT must be visually inspected with the naked eye and tested for loose or rattling parts by shaking.

19. TEMPERATURE STORAGE TEST

Purpose: Evaluates DUT capability to withstand storage conditions.

Reference: NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);

Test Parameters:

Total Test duration	3 months*
Temperature test	RT
DUT Test Position	Not relevant
Operating Mode	1.1
Functional status classification	N.A

Note 1: Only visual inspection is allowed during and after test. This test is not a part of ISO 16750 standard.

Note 2: test done by development.

Initial Evaluation of Test:

Before starting the environment test the DUTs shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Test Procedure:

1. Place the DUTs at temperature RT and keep them for 3 months.

Acceptance Criteria:

The DUTs have passed the environmental test:

- If requirements related to whiskers from visual inspection, according VCC supplement for ISO 16750: – 31822854, Rev.015, Vol.01, chapter 7.3- Environmental test 3 are full filled. Part shall be inspected by opening the housing.

NOTE: SEM images shall be presented to show compliance to whiskers requirement according to Visual inspection general section.

20. VISUAL INSPECTION GENERAL TEST

Purpose:

A visual inspection has to be performed after completed test sequence, connectors and other large internal components shall be removed/disassembled to enable visual inspection between these components and the PCB (Printed Circuit Board). Cross sectioning of solder joints and internal components may be needed. X-ray can be used as a first, non-intrusive inspection of solder joints and components, and is also helpful as a means for determining places to do cross sectioning.

Microscope with at least 40 x magnifications shall be used. At doubtful judgment a SEM (Scanning Electron Microscope) may be used. Pictures shall be included in report. In case that test report pictures are compressed in order to reduce document size, high resolution pictures shall be provided as attachment to the report.

Applicable Standard:

NOTE-DPR 33718830 Rev 06 (2020-08-14);
Note SPEC 31822854 – 015 (2019-07-09);
DIN EN 13018:2016-06;

Test Parameters:

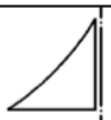
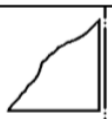
Visual inspection	
Number of samples	**All samples**

The ECU's will be verified for:

- Signs of degradation, cracks, melting;
- Solder/Part Lead Fatigue Cracks or Creep or Pad-Lift;
- Damaged Surface Mount Parts;
- Material Degradation, Growth, or Residues of Corrosion;
- The Formation of Whiskers and Dendrite Growth;
- Micro section on solder joints in order to detect any crack;

Requirements:

- No deformation is allowed (housing, PCB, connectors etc.)
- No change of color, gloss and surface structure that can be judged to affect function is allowed.
- No evidence of liquid (e.g. water, coffee, washer fluid) or salt intrusion inside the component is allowed.
- No evidence of whisker growth longer than 20 µm is allowed.
- No signs of wear or abrasion on wire insulation are allowed.
- No evidence of dust that could interfere with IP-class, correct function or impair safety.
- No evidence of CAF (Conductive Anodic Filament) is allowed.
- No evidence of electro migration or electro chemical migration is allowed.
- No evidence of corrosion products, that can be judged to affect fit or function, is allowed (for terminals/electrical components, this means no corrosion is allowed).
- No evidence of harmful residues (e.g. corrosive or aggressive halogens) that could interfere with correct function or impair safety.
- No signs of fretting related corrosion or wear are allowed.
- No delamination of printed circuit board is allowed.
- No sign of solder mask peeling is allowed.

	State 1	State 2	State 3	State 4	State 5	State 6
Section view of solder						
Top view of solder						
Description of solder surface	- Just after soldering process	- Enlargement of solder grain -Roughness and swelling of surface	- Outbreak of crack at the point of swelling and stress concentration (Crack < 1/4 of circumference)	- Growth of crack (1/4 ≤ crack < 1/2)	- Growth of crack (Crack ≥ 1/2)	- Loss of electrical conduction

Note 1: State 1 and 2 is acceptable.
Note 2: State 3 to 6 are considered to be defect.
Note 3: These inspection criteria are valid for both surface mounted and through hole mounted components.
Note 4: Shrink hole/hot tear (as defined in ANSI/IPC-A-610E, class 3) that has arisen during soldering process is not considered as a defect.

Initial Evaluation of Test:

Before starting the environment test the DUT's shall pass the preceding functional/parametric tests (as indicated by the test flow) and may not show any mechanical damage on the visual inspection.

Acceptance Criteria:

The samples are judged to be good, if the samples are free of any signs of dendrite growth, cracks, melting, damaged surface mount parts, residues of corrosion.